

Accounting for Climatic Changes to Reveal Areas with Anomalous Ecosystem Performance

B. K. Wylie and J. A. Rover

SAIC, contractor to the U.S. Geological Survey (USGS) Earth Resources Observation and Science (EROS) Center, Sioux Falls, SD 57198. 1-605-594-6078 wylie@usgs.gov. Work performed under USGS contract 03CRCN0001.

Interpretation of vegetation responses based on vegetation indices is influenced by noise related to short-term climatic variations. Short-term climate-driven variations in these indices can mask the effects of dominant species changes, management effects, and insect and disease infestations. We use a model to account for short-term climatic effects and use the remaining variations to quantify performance anomalies. The climate-driven model accounts for climate-driven variations in growing season normalized difference vegetation index (GSN), derived from MODIS 250 m NDVI used here as a proxy for ecosystem performance. Model outliers, pixels that were less green or greener than expected, represent ecosystem performance anomalies. The basic model assumption was that ecosystem performance is driven both by site potential and climatic conditions. This approach is applied to sagebrush land in Wyoming and southern Idaho.

Site potential, or long-term expected ecosystem performance, was mapped using regression tree modeling developed from a large number of random, homogeneous locations in Wyoming across multiple years (Figure 1).

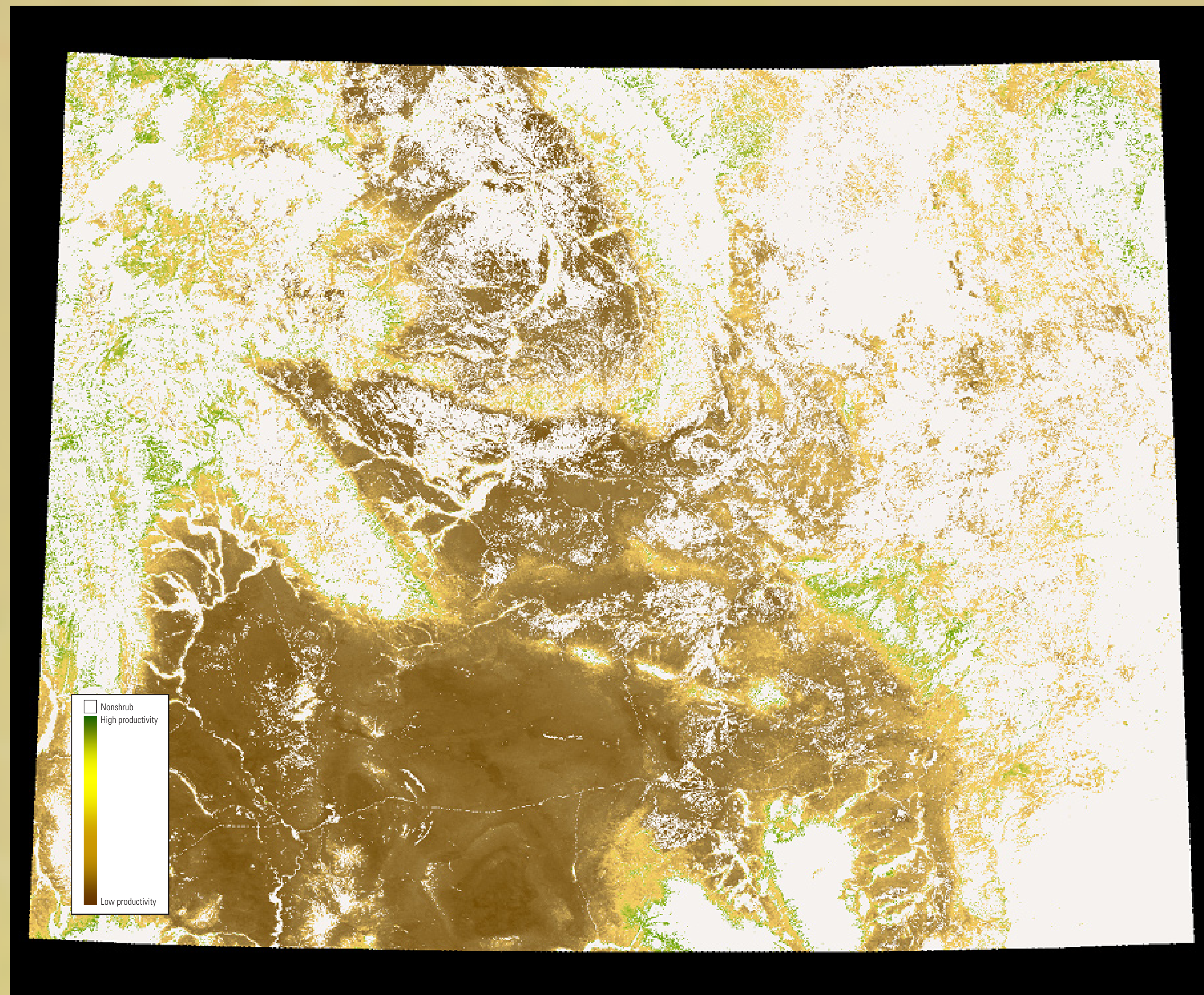


Figure 1. Modeled shrub site potential in Wyoming.

The site potential model for Wyoming estimated average 1989 – 2006 AVHRR growing season NDVI from sage type, NRCS Major Land Resource Areas, compound terrain index, land cover, north facing steep slopes, south facing steep slopes, variable continuous fields land cover, and STATSGO derivatives ($R^2 = 0.86$, Figure 2).

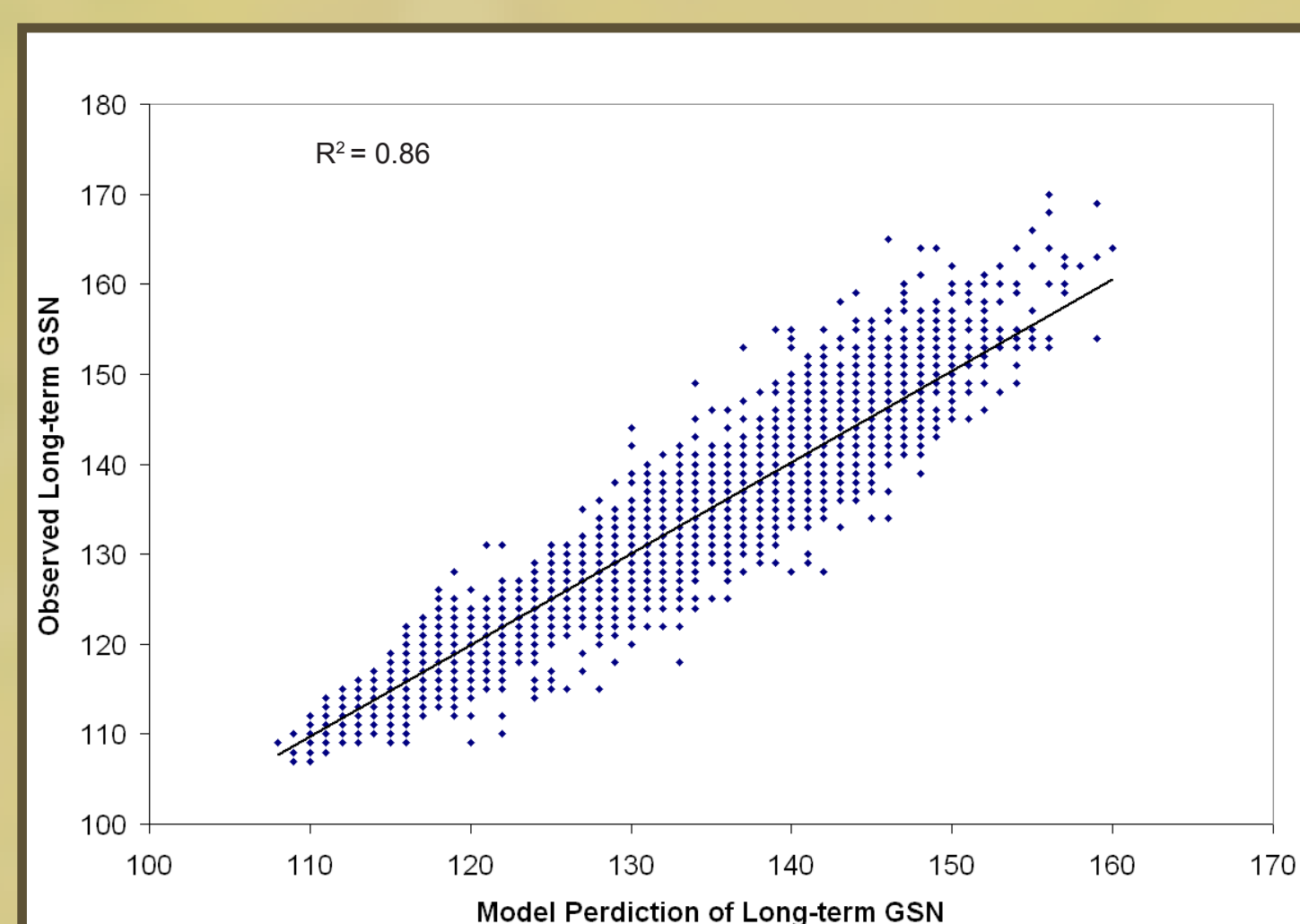


Figure 2. Wyoming shrubland site potential model compared with 1989 to 2006 growing season NDVI (GSN).

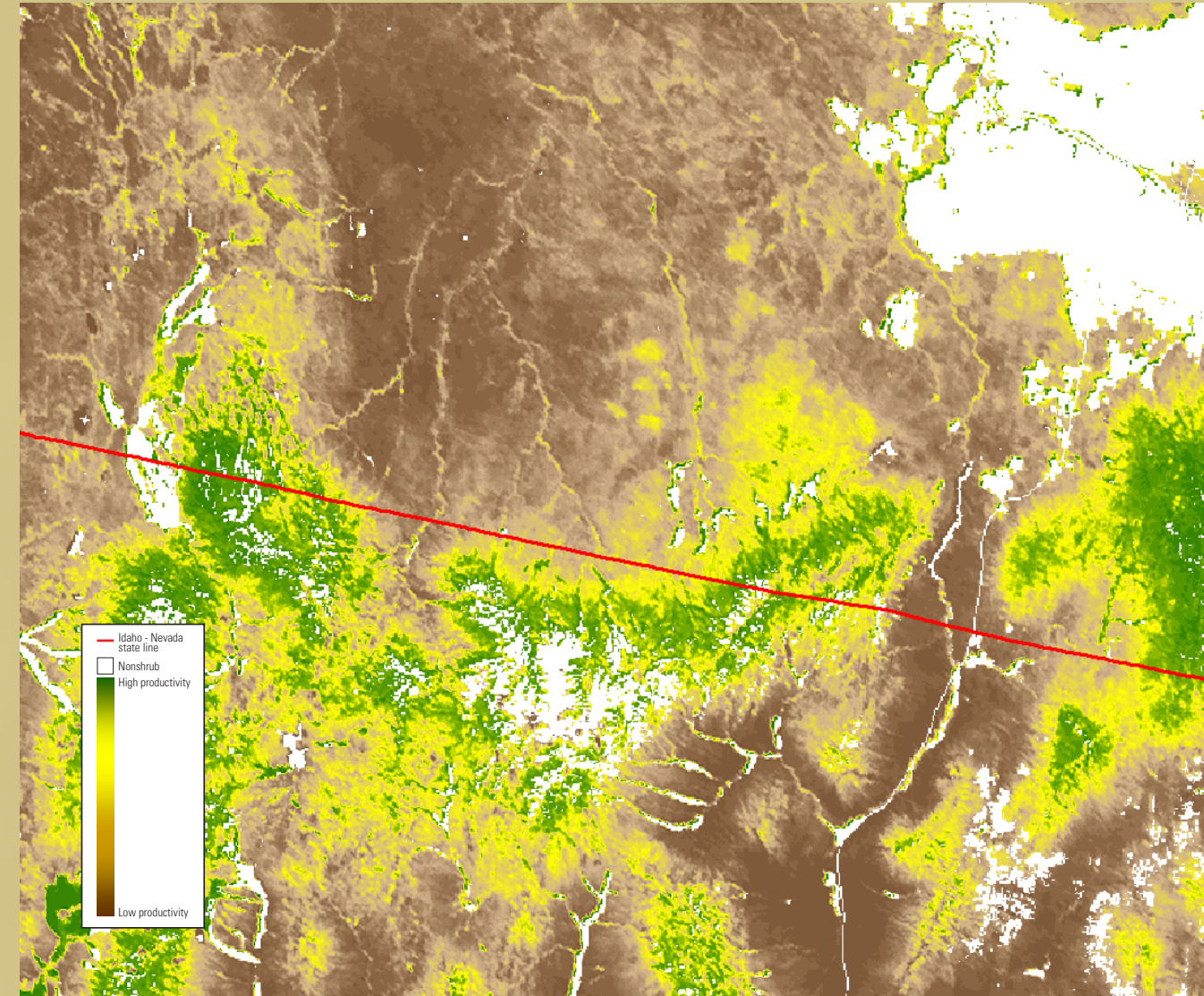


Figure 3. Shrubland site potential, Murphy Complex Fire, Idaho and Nevada.

Anomaly maps were produced for the years 2000 – 2005 in Wyoming and the year 2007 in Idaho. In Wyoming the number of years a pixel was underperforming or overperforming was quantified (Figure 5). For the sagebrush lands in Wyoming, the regression tree model which considered climate and site potential was developed from random locations and years ($R^2 = 0.91$, Figure 6). In Idaho, separate models were developed for grass ($R^2 = 0.86$) and shrub ($R^2 = 0.95$) dominated landscapes to map performance anomalies (Figures 7 and 8).

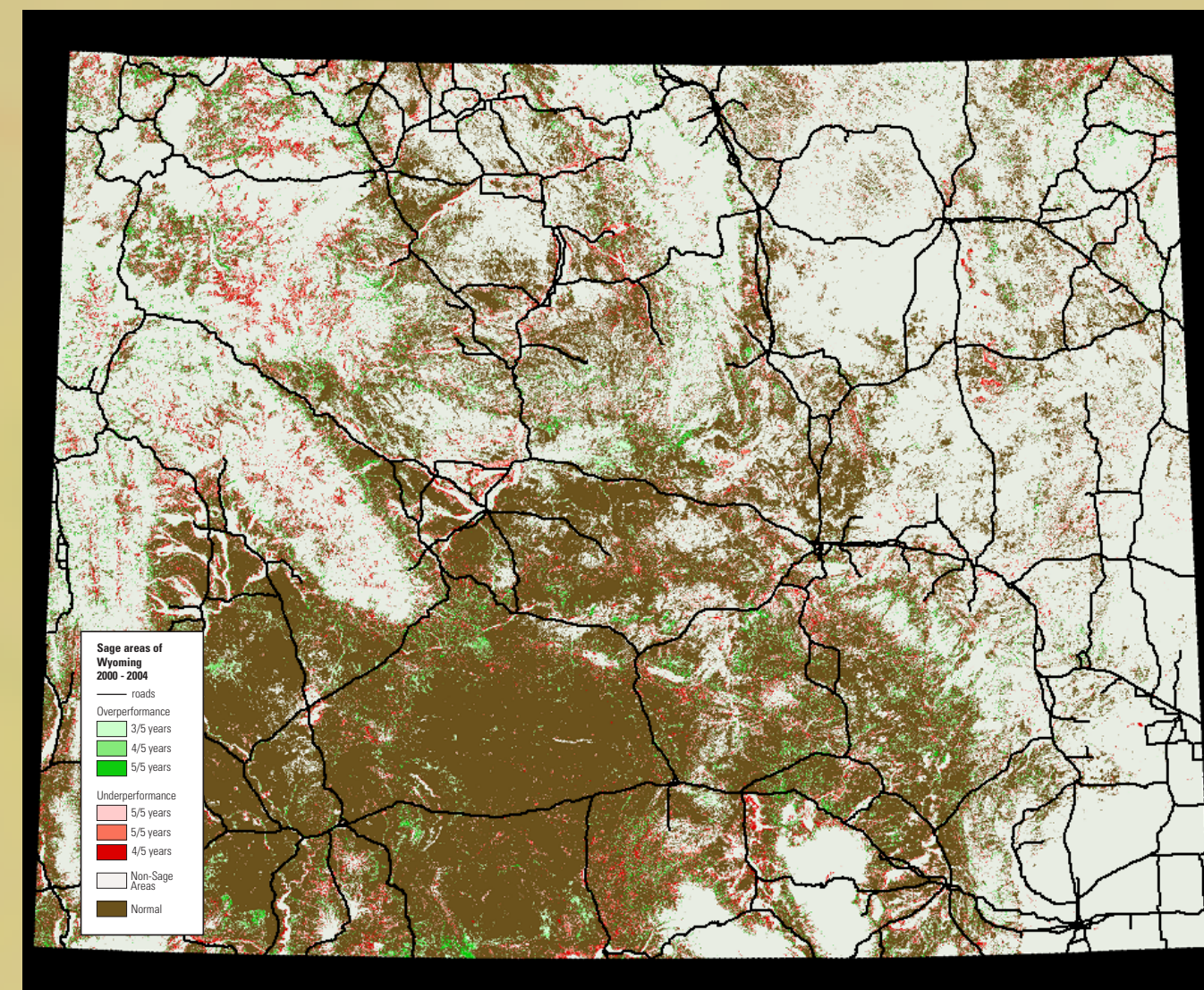


Figure 5. Shrubland performance anomaly annual frequencies.

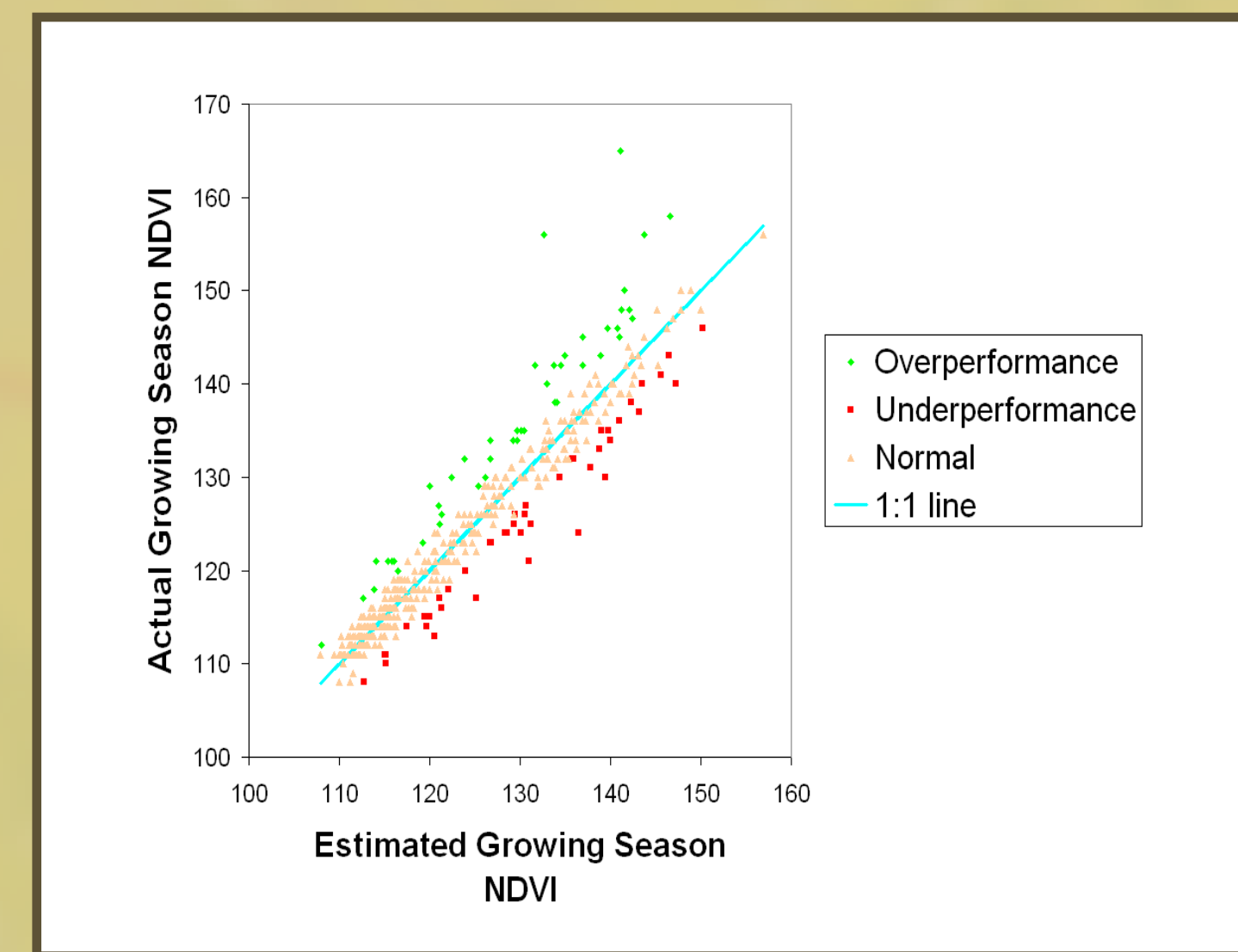


Figure 6. Expected ecosystem performance model anomaly thresholds for independent test data on Wyoming shrublands.

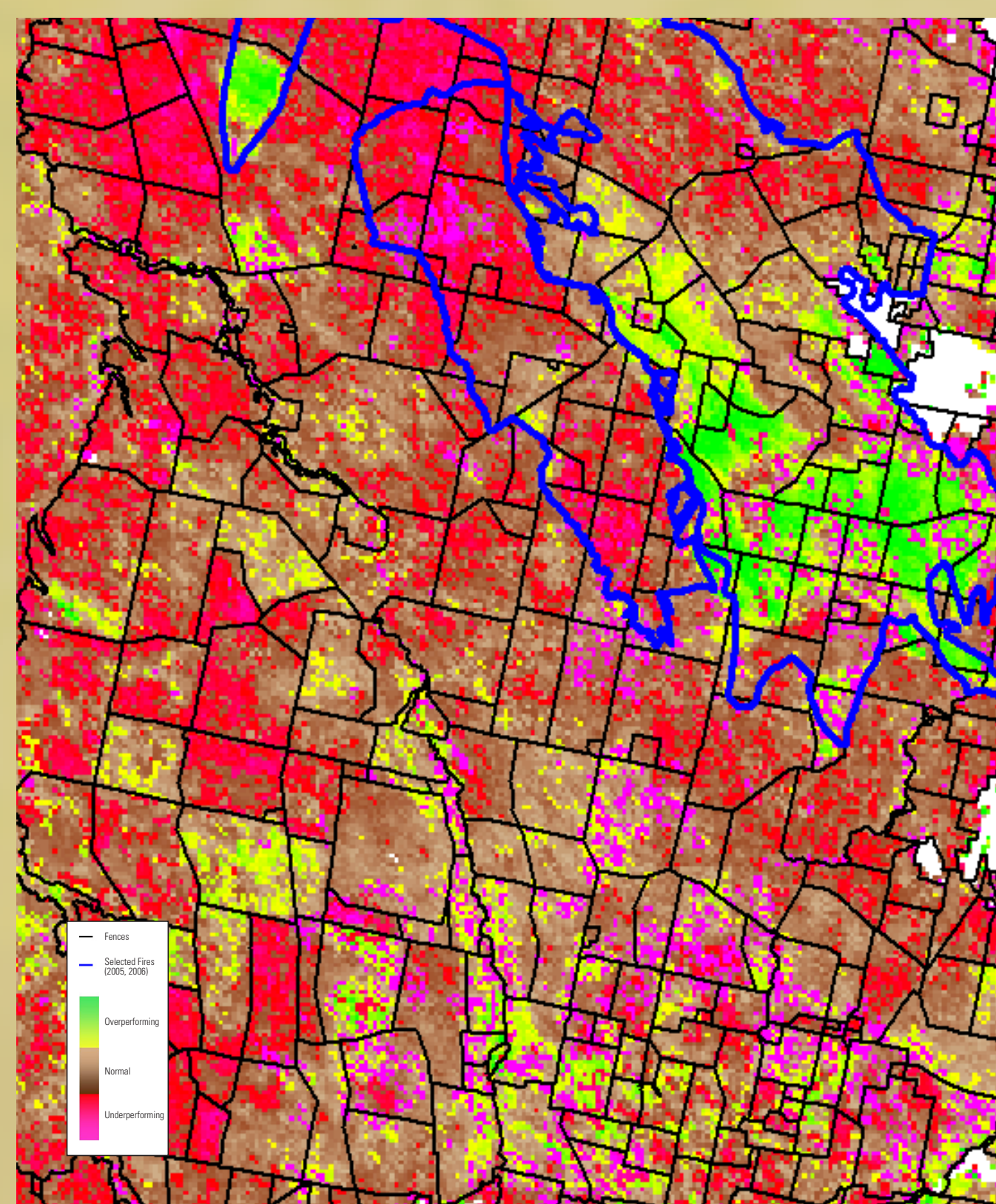


Figure 7. 2007 performance anomaly in southern Idaho agreed well with fence lines in the southwest and historical fires in the northeast.

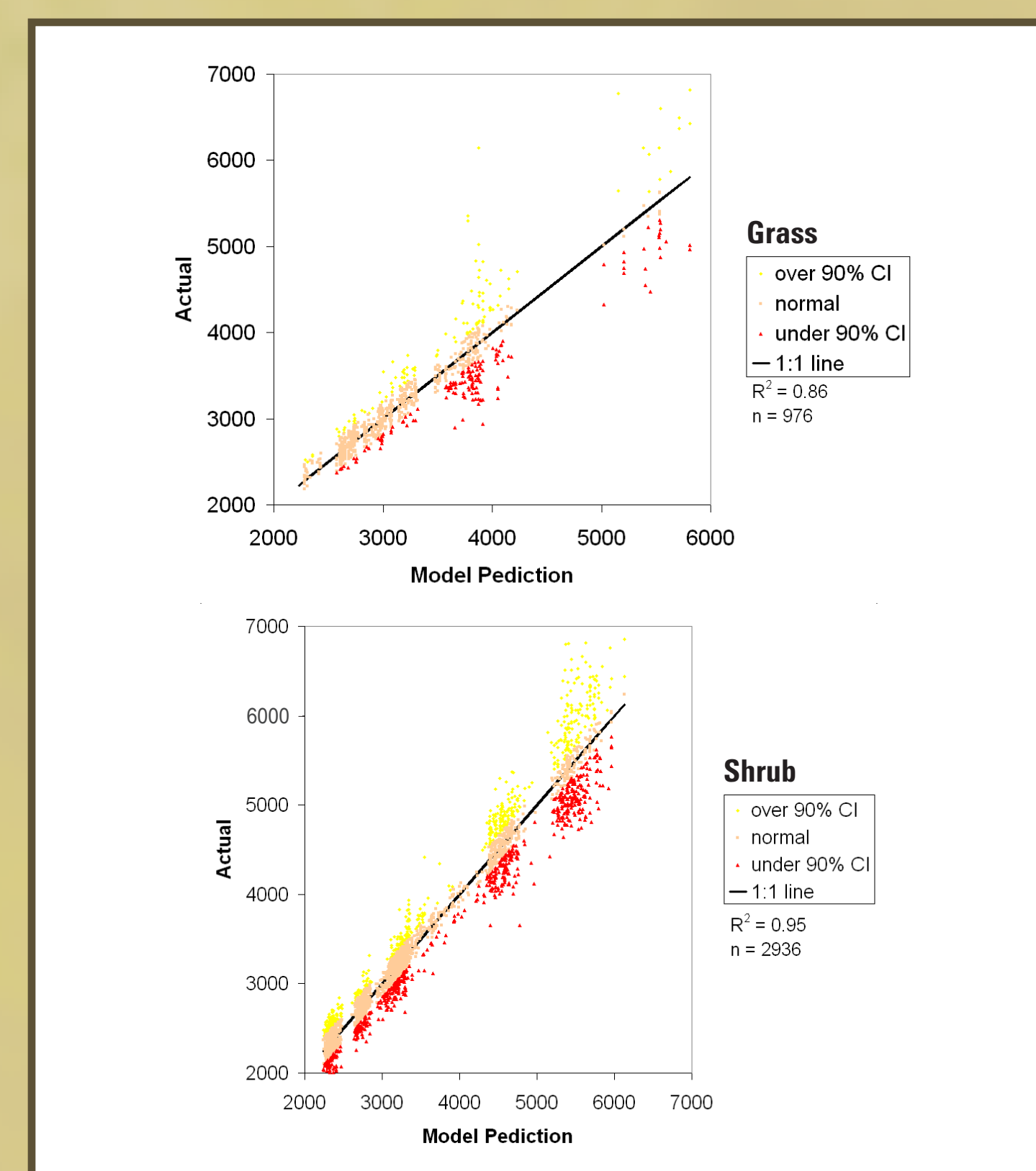


Figure 8. Expected shrubland performance grass and shrub models for southern Idaho showing anomaly thresholds.

Validation of underperforming anomalies in Wyoming with Landsat field-based percent bare ground (Homer et al., 2007) indicated that 66% of the underperforming test pixels had higher percents of bare ground than normal performing locations with similar site potentials (Figure 9). Validation of the Idaho data was done using actual 2007 grazing use records for selected pastures. In the grasslands of Idaho, actual grazing pressure was related to pasture ecosystem performance anomalies ($R^2 = 0.74$, Figure 10). Similar relationships for shrub areas in Idaho had significant noise. As a result, multiple year analysis of ecosystem performance anomalies and actual grazing pressure is required.

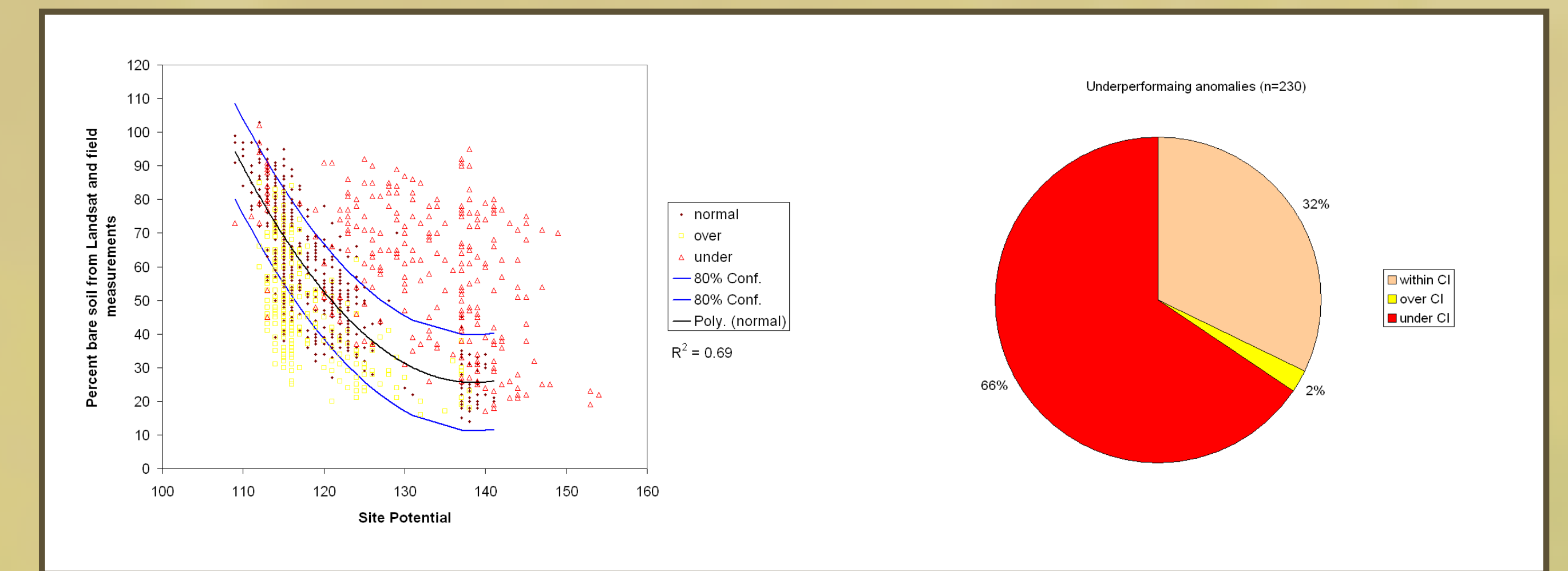


Figure 9. Validation of underperforming anomalies in Wyoming using Landsat field-derived maps of percent bare ground.

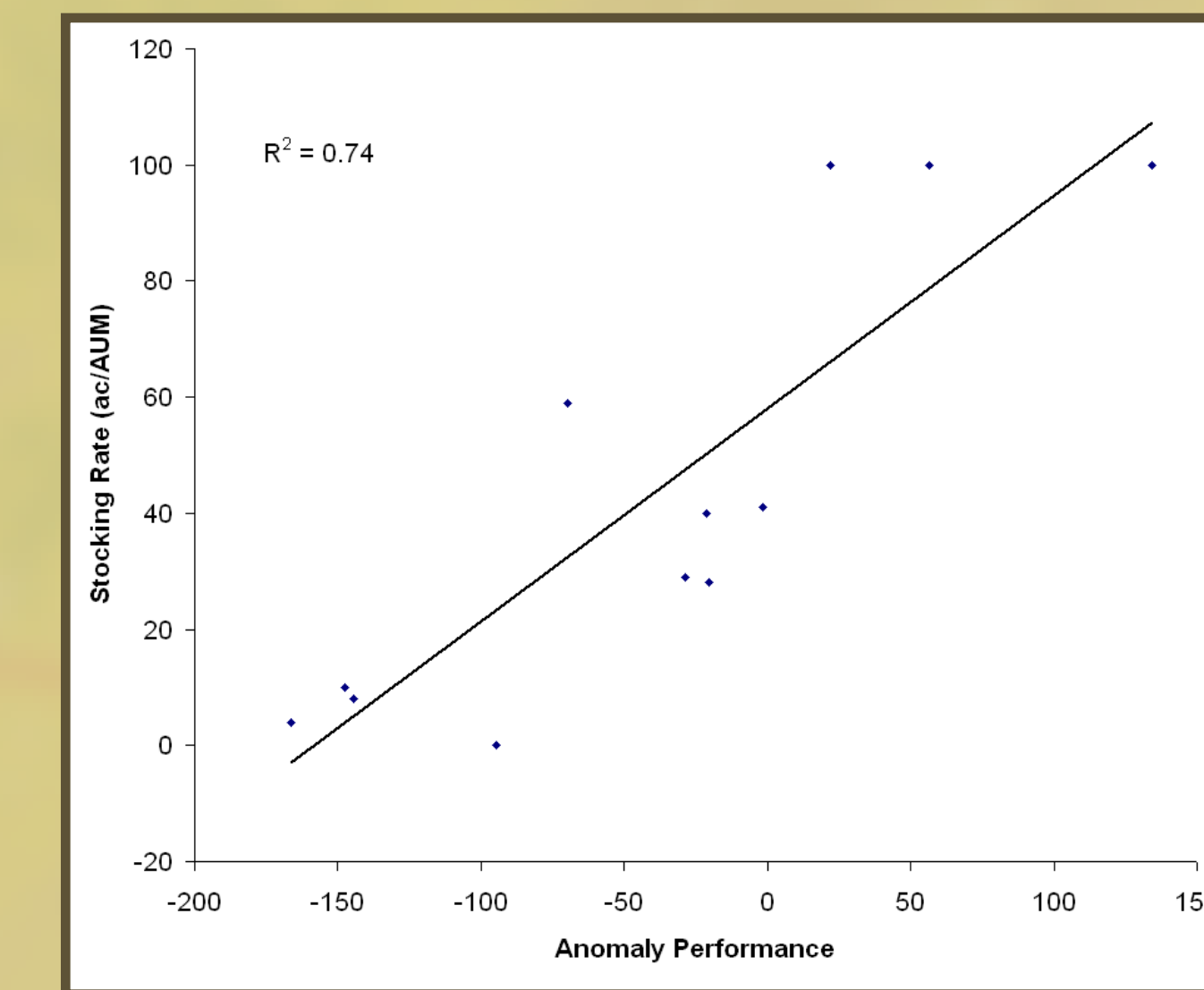


Figure 10. Validation of southern Idaho shrub performance anomalies using actual use livestock data.

Future plans:

- Continue validation efforts with BLM stocking rates.
- Incorporate eMODIS products.
- Quantify pixel dynamics in both the climatic and the disturbance axis.
- Investigate multiple land cover models' (e.g. grass and shrub) abilities to detect land cover shifts.

References

Homer, C.G., Aldridge, C., Meyer, D., Coan, M., and Z. Bowen. 2007. Multi-scale Sagebrush Rangeland Habitat Modeling in Southwest Wyoming, USGS Administrative Report, 18pp.